

GUIDANCE AND NAVIGATION FOR THE MARS ENVIRONMENTAL SURVEY PATHFINDER MISSION

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ABSTRACT

As part of the continuing exploration of Mars, the *Mars Environmental Survey (MESUR)* Project is being planned by the U. S. National Aeronautics and Space Administration (NASA) to acquire science observations of the surface of the Red Planet, from a network of globally distributed landers. Due to the unique features and complexity of this proposed network, a precursor mission known as *MESUR Pathfinder* has been developed to test several of the key technological capabilities which would be needed. Pathfinder is a low-cost (\$170 million, excluding launch services and flight operations costs) mission with a three year development period beginning in October 1994. The current Pathfinder mission plan calls for a single spacecraft to be sent to Mars, with launch occurring in December 1996 and arrival in July 1997. Upon landing, the spacecraft would initiate a 30 day period of surface operations, including the deployment and operation of a small experimental rover.

This paper will present an overview of the guidance and navigation scheme developed for *MESUR Pathfinder*, the navigation system being implemented for the mission, and an analysis of the anticipated performance of that system during the operations phase. The navigation problem posed by Pathfinder includes a number of challenging aspects, due to both the engineering design of the mission and the desire to keep the complexity of the spacecraft and its associated ground support systems at a minimum. One of the most significant features of the mission is the approach chosen for atmospheric entry, descent, and landing: the spacecraft will enter the Martian atmosphere directly from its interplanetary transfer trajectory, decelerate with the aid of a parachute and rocket braking, then reach the surface with a speed at impact of about 60 m/s, using an airbag system to cushion the vehicle from the shock. This unguided entry and descent scheme results in relatively stringent navigational accuracy requirements. The spacecraft must be guided to within about 20 km of the nominal atmospheric entry aim point to achieve the desired landing accuracy (75 km), and in any event guidance errors of no more than roughly 70 km can be tolerated, in order to ensure a successful landing.

To minimize the cost and complexity of the spacecraft and the ground operations system, navigation of *MESUR Pathfinder* will be performed with the use of only radio Doppler and ranging data acquired by ground stations of NASA's Deep Space Network. Guidance will be accomplished with a series of propulsive maneuvers commanded from the ground. The Pathfinder navigation system will be based upon existing software systems for orbit determination and maneuver design and analysis which have been used successfully in previous missions, in order to minimize development costs. There are a number of relatively new capabilities that will be employed in this system, however, such as the use of ranging data of sub meter precision for navigation, and a sophisticated sequential filter model for data reduction. These innovations will make it possible to obtain unprecedented navigational accuracies from a remarkably simple, robust, and cost-effective radio navigation system.

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